Personal protection device

The invention regards a method for manufacturing a personal protection device for use in contact sports, and other activities with a high risk for strokes or kicks to parts of the body.

In contact sports such as football, soccer, land hockey, ice hockey, rugby, etc, there are often physical impacts. Injuries following such impacts are common and can be severe and in many sports is it obligatory to use protective equipment such as shin pads, shoulder pads, knee pads, or other protection devices. For some kinds of labour there is also a need for protecting certain parts of the body to prevent injuries.

There is a problem with existing protective equipment for example for the leg/calf area for football/soccer that it does not protect the calf area. A stroke in this area can cause fractures and severe soft tissue damages. The available protective equipments in e.g. football, shin pads, are uncomfortable to wear, and the players often fail to wear them during training.

US 6298484 B1 discloses a protective guard comprising a shin guard, calf guard and an ankle sock. The shin guard and calf guard are connected in use by Velcro straps.

The shin guards and calf guards are standard components and are not custom fit to the user. This leads to less comfort for the user, and fully use of the muscles becomes uncomfortable if not impossible. This product is not widely used in soccer today.

US 5544663 regards custom fitting of shin pads or other body protection equipment to individual sportsmen. This is done by manufacturing one part of the shin pad of a moisture-curable material. The shin pad is placed against the shin of the sportsman to adapt the shape to the shin, and moist is added to start curing.

This is a complicated and time consuming method and the publication does not describe protection of the calf. A hit in the calf area can cause fractures in the leg, and it would be desirable to be able to protect also this area.

The object of the invention is to provide a method for manufacturing a protection device, that is comfortable to use and which protects the user without restraining the use of the muscles in the body part. It is also an object of the invention to provide the device itself.

The object of the invention is achieved by means of the features in the patent claims.

According to the invention, there is provided a personal protection device for protecting a part of a body of a user comprising at least two elements and fixing members for connecting the elements, wherein the elements have a curved inner surface, the curved surface being form-fitted to the shape of the body part to be protected by means of fitting to the outer surface of a model of the body part, the model being formed based on an image of the user's body part.

The device according to the invention comprises at least two elements and fixing members for connecting the elements. The number of elements will depend on the body part to be protected, the application of the device and/or on which sport event and level the device will be used. In football, for example, the device can be used for protecting the part of the leg below the knee, and two elements will be suitable, one for protecting the shin and one for protecting the calf. For protecting other body parts, other numbers of elements can be of interest, for example three or four elements for protecting the thigh/femur or one element for protecting the wrist. Usually, the number of elements will be chosen according to the exposed areas of the body part. For example as mentioned above for protecting the leg below the knee, the elements protect the shin to avoid fractures in tibia and the calf to avoid fractures in fibula, respectively.

The elements are form-fit to the shape of the body part to be protected to give the best protection and comfort for the user. A form fit shape facilitates distribution of any impact force over a larger area of the body part, thus leading to less risk for injury. The form fit shape also provides room for the muscles to expand, leading to both comfort and optimal performance for the user.

In one embodiment of the invention, the number and size of the elements are chosen to ensure that the elements in combination cover substantially all of the body part to be protected. In this or other embodiment(s) of the invention, the elements are shaped in such a way that the adjacent edges of the elements have complementary forms. In this way the elements may be arranged with a small or no gap between them to ensure complete protection of the body part and to provide a tubular assembly. The tubular shape provides torsional stiffness and an enclosed rigid construction to further protect towards injuries caused by torsion and providing extra support to the bone structure.

The elements are preferably covered by upholstery and in most cases a padding. The padding may be integrated in the upholstery or be a separate part. The upholstery and/or padding provides a more comfortable application towards the body part and may comprise a temperature and/or humidity transporting material between the body and the element(s) and/or a shock absorbing material on the areas facing outwards. The temperature transporting material may e.g. be Dri-Lex or other suitable materials for providing a comfortable temperature and avoid accumulation

of humidity which is both uncomfortable and may cause soreness of the skin. The upholstery and/or padding can be fixed to the elements by means of sewing, adhesive, nailing, clamping or other suitable means, or can be removable for changing or washing.

The fixing members are connected to the elements to interconnect them and/or to attach the device to the body. The fixing members are made of a material with some flexibility to further provide room for an expanding muscle, but which is rigid enough to provide sufficient pressure to the body part to stabilize it, e.g. a semi-rigid material. Pressure exerted on the muscle compartments surrounding the bones stabilise the bones and leads to less risk for injuries. The fixing members can be attached to the elements, or to the upholstery/padding.

The fixing members may for example be adhesive tape, strings, straps, etc. In one embodiment the fixing members are Velcro fasteners.

The fixing elements may also be a hinge device/hinge joint which interconnects two or more elements along at least one edge. This hinge element may also be designed to be semi-rigid.

The device is manufactured by performing the following steps:
- providing an image of the shape of the body part to be protected,
- based on the image of the body part, milling out a model of the body part,
- providing at least one blank with a curved inner surface, the surface form being adapted to the outer surface of the model, and
- cutting and/or finishing the edge of the blank(s) to obtain the desired shape.

The image of the body part to be protected can be provided by means of imaging devices, such as digital cameras, IR cameras, film cameras, single CCD chips, etc. In one embodiment the image is acquired by means of moving a number of cameras surrounding the body part along the full length of the body part. The cameras may e.g. be arranged in a pattern adapted for surrounding the body part, e.g. a substantially circular pattern, a square pattern, or any suitable pattern which can provide the desired amounts of imaging points sufficient for providing a 3-dimensional image of the whole body part. The image data from the cameras may be processed by means of image processing means, such as e.g. a computer or dedicated processing means adapted for providing the desired data format. Some processing may also be performed for correcting obvious errors in the images and/or add or remove features from the image.

Image data from the cameras are transferred to a milling machine where they are used as input data for milling out a model of the body part of interest. The milling machine is preferably a three dimensional milling machine for production of a model of an imaged object. The milling machine may be adapted for receiving and

using the processed image data from the imaging devices, or the milling machine itself may comprise image data processing means.

The model produced by the milling machine is used for forming the blank(s). The blank(s) should have a curved inner surface which fit the body part to be protected to ensure optimal support and comfort for the user.

As earlier mentioned, there may be provided one or a number of blanks, the number depending on the body part to be protected, the application of the device, and on which sport event and level the device will be used. In one embodiment there is provided at least two blanks which in combination covers substantially all of the body part to be protected.

The blank(s) is made of a material with sufficient strength, rigidity, power distribution capability, and which is light and ductile.

In one embodiment the blank is made of a thermoplastic material. Such a material is rigid and has a stable shape when under a certain transition temperature, while being ductile when heated over the transition temperature. In this embodiment, the blank is provided by thermoforming a sheet of thermoplastic material. The sheet is formed by first heating it above the transition temperature to make it plastic. The plastic sheet is then brought into contact with the model and pressed against the model to achieve the desired formed blank.

In one embodiment the blank comprises a carbon composite material which is light and strong. The carbon composite material may be saturated with a ductile material, for example a thermoplastic material as mentioned above. The forming may thus be performed as described before. The forming can also be performed by first threading a net of carbon fibres over the model, then applying a ductile curable material, e.g. a thermocurable material, thus after curing having gained the shaped blank.

In another embodiment the blank is made of a carbon fiber material with or without aramid fibre (Kevlar) which is pre-saturated by an epoxy plastic. The model should then be applied a slip agent on its outer surface before carbon fibre mats are arranged onto the surface in different angles. For example may four layers of carbon fibre mats be applied with mutual angles of 45 degrees, which provides a thickness of approximately 0.7mm for the blanks. The carbon fibre layer is then covered by another slip agent and the model is put under vacuum and exposed to heat, for example in an oven, for curing, eg. 90°C for 6 hours.

The blank may alternatively be made of other formable and curable material with sufficient strength when cured. Other suitable forming methods may of course also be applied.

After curing, the blanks must in most cases be further finished to obtain the desired formed edges. The edge forming may be performed by cutting, sawing, filing, grinding, or other suitable forming method. In one embodiment with two or more blanks, the edges may be formed to provide that the adjacent edges of the blanks have complementary forms. This ensures a close fit between the blanks, thus preventing any part of the body part from being exposed to outer forces and thus being injured, and preventing the blanks from dislocating. In this way a tubular assembly can be achieved providing torsional rigidity and thus improving the supporting feature of the device.

To obtain an even more comfortable product, the blanks may be provided with upholstery and/or padding. The padding may be integrated in the upholstery or be a separate part. The padding is preferably facing the body part. The padding can be connected to the blanks by means of nails, pins, sewing, adhesive, etc. The upholstery can be connected to the blank in the same manner, or the upholstery can be provided with pockets for inserting the blanks. The upholstery can also be provided with pockets for inserting the padding.

The padding may be disposable or washable to enable the user to have a fresh and clean padding each time the protection device is used.

The padding may also be provided with ventilating means such as channels or holes. The ventilating channels may be arranged directly in the padding, or in the padding/blank interface. There may also be provided ventilating holes in the blanks.

The blanks must be connected to the body for providing the protection. The blanks may be connected to the body by means of adhesive tape, strings, straps, etc. In one embodiment the blanks are connected to the body part by means of Velcro fasteners. The Velcro fasteners may be a separate part, may be connected to the blank(s) or to the upholstery/padding.

In the above, the device is described as being custom fit to each user. It is however possible to use the same manufacturing method for manufacturing less customized, but still form fit, devices. The model may be produced based on data gained from experience data or from synthetically produced data.

One possibility is to measure characteristic features of the body of many people, possibly average them, and classify them by size and/or shape. In this way a set of sizes may be provided. A number of models and corresponding blanks/devices may then be produced based on these data, and a user can choose between these to have a device with excellent fit.

One possible solution for choosing the adequate size/shape of the blanks may be to scan the body part of interest to achieve data regarding a number of characteristic

features of the body part. The scanning may be an imaging device and the characteristic features may be e.g. the length of a leg from the foot to the knee and the circumference of the leg in three different locations. The characteristic features may be derived from the scanning manually or by means of data processing equipment which may be permanently connected to the scanning device, or may be a separate unit. The characteristic features may then be compared to the set of sizes described above, and the size which gives the best match may be picked out. In a more simple procedure, the characteristic features may be manually measured and the best fit size picked out of a table.

The invention will now be described in more detail by means of an example with reference to the accompanying figures where:

Figure 1 is a schematic representation of the method according to the invention for producing a protection device.

Figure 2 is a detailed view of one kind of protection device.

Figure 3 is an example of an embodiment of a protection device according to the invention.

Figure 1 is a schematic representation of one embodiment of the method according to the invention for producing a protection device. The elements of the protection device which result from the steps of the method is shown in figure 2 and will be described accordingly.

First the body part to be protected is scanned in 11. The scanning means providing a three dimensional image of the body part. In this example the body part to be protected is the leg below the knee, e.g. a shin guard protecting both the shin and the calf of the leg. The leg may be scanned by means of a commercially available shape capture device such as the Omega T-ring, a product of Tracer, A Division of Ohio Willow Wood. After scanning, the image may be adjusted or corrected in 12 by means of image processing means.

The image data is transferred to a milling/carving machine such as the OrthoCarve™ from Ortho Europe for milling out a model of the leg 13, called a "plug". The model is then split in two parts in 14. The two parts corresponds to two parts of the protection device, one front part and one back part.

The two model parts are then used for forming blanks in 15. The blanks are for example made of a laminate comprising a 1.5 mm carbon fibre sheet saturated with polyamide plastics. The forming of the blanks is performed using a diaphragm forming technique or other adequate forming technique. In diaphragm forming, the sheet is heated between two release films, normally from silicone rubber. The softened laminate with the release films is than quickly placed on top of the model,

after which the diaphragm is closed and air pressure of around 5 bars is applied to press the sheet towards the model. After the material is sufficiently cooled down the product has gained its desired form.

In 16 the blanks are cut to obtain the desired form of the edges of the two parts of the protection device. The form may be individually adapted according to the user's wishes and physical needs, especially the height of the leg protection device can vary substantially from person to person. In 17 it is performed further edge processing for obtaining the optimal form, adapting the two parts to each other, and/or remove any sharp edges.

In 21 padding is provided by thermoforming a thermoplastic material such as EPE/EVA foam. In 22 the padding is cut by means of e.g. a stamping machine or by cutting by hand to adapt the shape to the blanks.

In 31 any finishing details are provided, such as edge finishing.

In 32 are textiles produced, i.e. upholstery for covering the protection device. The upholstery and/or padding provides a more comfortable application towards the body part and may comprise a temperature and/or humidity transporting material between the body and the element(s) and/or a shock absorbing material on the areas facing outwards. The temperature transporting material may e.g. be Dri-Lex for providing a comfortable temperature and avoid accumulation of humidity which is both uncomfortable and may cause soreness of the skin.

In step 33 there is possibility for further customising of the device and in 34 the seams, any edge features, straps, Velcro fasteners, decorating elements etc, are provided and attached to the padding and/or blanks.

In 35 the blanks and padding are assembled to form the final device.

Figure 2 is a detailed view of an example of a protection device according to the invention. The device is in this example a combined shin/calf guard for protecting the leg below the knee of a sportsman. The device comprises two blanks 40, 46 of Tepex, which are produced by thermoforming, thermoformed padding 41, 45, one for each blank, edge details 42, 44 and Velcro fasteners 43a, 43b.

The parts shown in figure 2 are assembled and provided with upholstery in step 34 in figure 1 to provide a finished protection device.

Figure 3 shows a similar embodiment as shown in figure 2, but with some different features. The protection device comprises also here two parts, or two "shells" comprising blank and padding. The height and width of the shells may be individually adjusted according to the user's wishes. The shown embodiment provide a protection device with no gap between the two parts when assembled 50

for use. The assembled device 50 has a tubular shape, and this leads to excellent protection towards external impacts and torsional forces, while also providing a pressure in the tissue which supports the leg to further prevent fractures.

The examples used here is for protecting the leg below the knee, as is particular interesting for sports such as soccer/football, rugby, hockey/land hockey, etc. It is however clear that the method according to the invention can be applied for manufacturing protection devices for other body parts and for other applications, for example for other sport events and/or industrial or other applications which demand protection equipment for protection against impacts which may lead to fractures or body tissue damages.